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Contamination of Toxic Heavy Metals in Various Foods in Iran: a Review

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Abstract

Introduction: Heavy metal is used to refer to metals and semi-metals with a density of more than 5 gr/cm3. The rapid developments of the new technologies in numerous projects and soil contamination by heavy metals, make the soil structure poisonous for plant growth and development, and they all damage the soil biodiversity. Water is also essential for the survival of all living organisms, but unfortunately sources of water used in industries are suffering from all kinds of pollution. The aim of this study is to review the level of food contamination with toxic heavy metals in Iran. This study was a descriptive overview with entry criteria, relevant information and the keywords of the research.

Methods: Databases Science-Direct, Scopus, PubMed, SID and Google Scholar databases were searched.

Results: 40 studies were eligible for entry and spread of toxic metals in some foods was defined out of range.

Conclusion: According to the results of some recent studies, the high concentration of toxic heavy metals in a variety of foods available in Iran's market and the significant role of these foods in people's diet, it can be said that there is significant information gap in this regard. These studies will be directly used in the risk assessment of heavy metals through the consumption of food products.

Key words: Heavy metals, Toxic metals, Food, Water, Iran

INTRODUCTION

Heavy metals and semi-metals refer to metals with more than 5 grams' density per cubic centimeter and atomic weight of 5,63 to 3,200. These elements are toxic for the organisms in concentrations above the critical threshold; however, some of them in lower concentrations such as iron (Fe), manganese (MN), copper (Cu), zinc (Zn) and selenium (Se) are essential for metabolism [1]. In Water, heavy metals are first absorbed by phytoplankton, bacteria, fungi and other tiny organisms which later are eaten by Larger species and eventually enter the human body [2].We would be able to understand and discover the underlying causes of several diseases due to the presence of metals as natural components in foods , consumption of the contaminated substances from the environment as well as the consumption of the foods which were exposed to heavy metals during the technological process [3], and also through measuring the concentration of toxic heavy metals in common foods such as salt, bread and water which have important effects on public health [4].

TOXIC METALS

Lead, cadmium, mercury and arsenic are among the most risky heavy metals when consumed through contaminated food. Of all the heavy metals, cadmium and lead have more significant side effects on human health since they are easily accessible through food chain transmission, however they are not essential for biological function [5]. Compared to adults, children are more sensitive to the accumulation of these metals in body tissues [5]. As a result, the accumulation of these metals cause serious complications, including mental retardation in children, adverse effects on the functions of kidneys and on cardiovascular and auditory systems [5]. Numerous studies worldwide are being carried out regarding heavy metals as contaminants in food [4, 6].

Cadmium is an element with an atomic number 112.4. It has entered and contaminated groundwater supplies, soil and lakes through its application in some chemical fertilizers (phosphate fertilizers) which inevitably affects crops, different animal species and fish [6]. Cadmium can cause Kidney lesions, hypertension, mutagenesis and carcinogenesis [6]. The most important adverse effect of cadmium in human, is Itai-Itai disease which directly affects calcium and bone metabolism [7]. and was first reported in Japan as it was consumed through contaminated rice.

Arsenic is a semi-metal with atomic number 33 which can be found almost anywhere on the planet. Its exposure could cause liver disease, diabetes, cardiovascular problems, skin disease and cancer. Arsenic poisoning has already been reported in several countries, including Iran, since it could easily get into water sources and the environment due to its application in different industries such as animal agriculture and medicine [8].

Lead is an element with atomic number 32 and after iron, is the most commonly used metal. Lead has entered agricultural products due to the use of chemical fertilizers, herbicides, sewage treatment and contamination of soil by sewage. This metal is significantly toxic and accumulates in the body which results in acute poisoning in humans [2]. Moreover, if the water has acidic pH, it will cause poisoning and absorbs lead while it passes through the water pipes [9]. Hematopoietic system, nervous system and renal system are the three main body systems sensitive to this metal. [8,10].

Mercury is a metal with atomic number 80 and it could be absorbed by inhalation, ingestion and through the skin. Mercury vapor tends to affect central nervous system, kidneys and liver. Studies have shown that inhalation of mercury vapor, can cause problems such as immune system disorders, kidney dysfunction, infertility, adverse effects on fetus, neurobehavioral disorders, heart failures and Alzheimer. Relatively, the use of methyl mercury as fungicide in protecting seeds have resulted in depopulation of the birds which had eaten the contaminated seeds [10].

METHOD

To access the relevant literature, we used these keywords; “heavy metal", "food", "water" and "toxic metals" from Science-Direct, Scopus, PubMed, SID and Google Scholar databases. All the articles and references were reviewed based on scientific papers published in the databases. Of all the 67 heavy metal studies in Iran, 41 studies were about toxic metals as contaminants in foods.

RESULTS AND DISCUSSION

Drinking water

Studies related to contaminated drinking water could reveal various health problems [11]. A study was conducted by Dr. Mosaferi *et al* (1387) on the amount of arsenic in drinking water in shahrood, (200 villages). In this study, 50 villages had arsenic-contaminated water and among them, the water of 9 of the villages were reported to be contaminated above the standard limits (50μg/L) [11].

Aquatic

Sea foods as one of the most important nutrients could be also contaminated with toxic heavy metals. Agricultural activities alongside the rivers could be one of the reasons of the entry of wastewater caused by chemical fertilizers and agricultural toxins into the rivers which can directly affect freshwater ecosystems and the water species habitats. Heavy metals are one of such pollutants and among them, mercury, lead and cadmium cause severe poisoning in humans and animals. Industrial and non-industrial sources of mercury contaminate water. In our country, some research has indicated that the mercury levels in fish from the shores of Persian Gulf is above the limit [12]. These metals enter cells when combined with enzymes and carrier proteins and then have their destructive effect on cellular functions [12]. The side effects of the above pollutants on human health occur mainly during chronic and acute exposure to these toxins. They cause liver, kidney and bone damages and also they are potentially carcinogenic, mutagenic and allergenic [12].

Heavy metals which can be found in fertilizers include; arsenic, cadmium and lead, constant application of arsenic contaminated fertilizer and consequently their absorption by the plants can directly influence and pollute food chain. Those who regularly consume rice are exposed to significant amounts of heavy metals [13]. Several studies on toxic heavy metals in rice have been conducted in Iran which is shown in Table 2.

Vinegar

Vinegar has always been a popular seasoning especially for Iranians. A study was first conducted by Dehkordi *et al* in Iran (2011), with the aim of assessing the concentrations of heavy metals (lead and cadmium) in different types of vinegar produced in the country, including dates, white grapes, red grapes and apple (24 specimens of each type) which were collected during six months. In this study Chronopotentiometry Stripping method(SCP) was used to determine these elements. The results showed a statistically significant difference between the concentration of lead and copper in vinegar (0.05<p).The comparisons of the results of the metals studied within the proposed standards for each metal in vinegar (the standard number 355) showed that none of them exceeded the maximum limit and no risks threaten Iran’s human society. The results of this study also showed that the concentrations of all samples were below the standard maximum extent (Institute of Standards and Industrial Research of Iran) [14].

Bread

Bread provides more than 50-90% percent of the protein and calories needed by the body. Heavy metals can enter crops and eventually bread and cereal. Flour manufacturers can also be contaminated with heavy metals when the water used during the preparation of dough is contaminated with heavy metals. In addition, bakeries’ fuel type influences the deposition of heavy metals in bread. Bakeries locations in the city and those close to the industrial centers are also of importance [9]. A study was conducted by Khaabnadideh *et al (*1379) to determine the amount of lead in bread in 5th district of Shiraz (83 bakeries in the area), they have used atomic absorption method. The results indicated that lead levels in bakeries’ consumed water and salt were below the standard limit (0,03ppm). However, the lead in the flour used in 73 bakeries in the city was less than the limit which was acceptable and it exceeded the standard limit in 9 of the bakeries [9].

Salt

A study was carried out (1390) using atomic absorption spectrometry in order to measure the heavy metals (lead and cadmium) in salt which was purified through rinsing with water and then compared to rock salt. The results showed that the average concentration of lead and cadmium residues in salt had no significant difference with the rock salt and a significant change is observed in rock salt’s purity when it is treated with water. Additionally, cadmium seemed to have the lowest and iron the highest values in refined salt [4]. In another study by Cheraghali *et al* (2010) salt contamination with heavy metals such as; lead, cadmium, mercury and arsenic was analyzed. This study was performed on 100 samples using atomic absorption method. The results showed that the concentration of the analyzed heavy metals in salt was less than the maximum standard levels and no significant difference was observed between the metals in rock salt and refined salt [15].

Oil

Oils and fats, like other food products always contain some different metal residues that might have been contaminated through natural ways (soil, water, fertilizers and pesticides) or during the transportation, processing and storage.

Regardless of the source, the presence of metal residues in oil even in very small amounts is considered undesirable and negatively affects the quality levels. Metals such as lead and arsenic in oil have high intoxicating effect and it is important to precisely control the amounts (AboAli, 1371).In a study carried out by Abbasi *et al* (2009) lead was determined in 24 samples of edible oil using Pulse Adsorptive Stripping Voltammetry. The results of this study showed acceptable limits of lead concentration in oil [16]. Another study was also conducted by Farzin *et al* (2014) to determine metals (lead and cadmium) in edible vegetable oil produced in Iran using atomic absorption technique. The results of lead and cadmium in all the oils was evaluated under the standard level FAO / WHO [17].

Tea

After water, tea (either green or black) is the most widely consumed beverage because of its taste, aroma and health benefits. Of the estimated 2.5 million metric tons of dried tea manufactured annually,75% is processed as black tea and it is consumed by many countries [18]. Studies related to metal contaminants in tea are available in Iran. (Table3)

Vegetables

Vegetables are important components of a healthy diet and based on scientific evidence the consumption of vegetables can reduce the risks of heart diseases and some cancers, especially gastro-intestinal cancer. Vegetables that are irrigated by contaminated water such as industrial and urban sewage, increase the possibility of the presence of heavy metals in farmed vegetables [6]. Table 4 shows the studies conducted on toxic metals in vegetables in Iran.

Meat

Meat is one essential and basic nutrient, rich in minerals. Subsequently, it is an important factor in food chain. The increase of foodborne diseases has attracted a lot of attention from the health authorities. One reason is the toxicity of heavy metals in animal products [19]. Table 5 shows the studies conducted on toxic metals in livestock products in Iran.

Table 1. Heavy metals in aquatic of Iran

Studies	Results
Prevalence of heavy metals (cadmium, lead)In two species of fish in the Persian Gulf (Bushehr)By ICP	In both species the highest and lowest content of heavy metals copper and cadmium were reported The cadmium less than the amount determined by FAO / WHO But the amount of lead in the sample was higher than the international limit. [20].
Assessment of heavy plateau (mercury, cadmium and lead) in canned tuna produced from 4 sources in Iran By ASS	4 sets of samples of mercury (100% of the allowable range), The cadmium (75% of samples above the limit) The lead (50% of samples above the limit) [21].
Comparison of heavy metals (cadmium and lead) in farmed and wild rainbow trout fillets	41% cadmium levels in samples of farmed and wild samples higher than 45% in Europe. %50 of lead in samples of farmed and wild specimens 62 percent higher than in Europe [22].
Heavy metals (cadmium, lead and arsenic) in 21 cans of canned tuna from the Persian Gulf	The results of this study showed that tuna Persian Gulf, Iran has allowed the concentration levels of the FAO / WHO [23].
Determination of Lead, Cadmium in 6 species of fish from the Persian Gulf .Using the potentiometric stripping analysis derived	The estimated daily and weekly intake of lead and cadmium estimated monthly consumption through consumption of fish below the values PTDI, PTWI and PTMI value established by the FAO / WHO [24].
Seasonal accumulation of toxic elements in 120 samples of the fish species of the Caspian Sea By GFAAS	The estimated daily and weekly intake of lead and cadmium estimated monthly consumption through consumption of fish below the values PTDI, PTWI and PTMI [25].
The concentration of heavy metals (arsenic and cobalt) in 10 samples of shrimp and crabs By INAA	The concentration of cobalt and arsenic in shrimp lobster crab and shrimp less than the above limit [26].
Accumulation of heavy metals (cadmium, cobalt and lead) in the context of five fish species (for every 10 samples) in the Caspian Sea By ICPMS	The toxic elements (cadmium, lead, cobalt) was lower than the international limit [27].
Determine the accumulation of heavy metals (cadmium and lead) in the body carp in the river Aras (5 stations fishing)	The highest amount of Pb in catches from the least amount of cadmium was reported 5 stations [28].

Table 2. Amount of toxic heavy metals in rice in Iran

Studies	Results
Evaluation of arsenic in rice grown in Fars province By ICP (38 sample of 22 villages)	Arsenic levels in 100% of samples above the limit set by WHO / FAO, respectively [13].
Contamination of cadmium, lead and arsenic in 10 samples of imported rice consumed in Tabriz Using atomic absorption spectrophotometry	Weekly consumption of cadmium, lead and arsenic in rice tolerable weekly intake limit recommended by FAO / WHO was. Arsenic levels in all samples were below the limit. In connection with Cadmium, 40% of the samples was beyond

	Standard %60of the samples was the limit. In the case of lead, 80% of the samples outside the standard range 20% of the limit was1[29].
Determination of Pb, Cd, Cr in 20 samples of imported rice in India Using atomic absorption spectrophotometry	The average level of lead in samples of rice was slightly higher than the FAO / WHO The index PTWI for lead, cadmium, chromium was lower than the international limit [30].
Concentrations of cadmium, lead, chromium and cobalt in the cultivation of rice imported and domestic (7 Brand and 5 samples for each brand) in Shiraz Using the atomic absorption method	Lead and cadmium in all samples of domestic and imported values greater than FAO / WHO was In domestic brands have the highest levels of these metals in the south of Kamfiruz and imported brands of the brand Salam [8].

Table 3. The amount of toxic heavy metals in tea in Iran

Studies	Results
The concentration of heavy metals (arsenic, mercury and lead) in 15 tea samples (5 domestic and imported brands) in Mashhad Using the atomic absorption method	Absorption of mercury 70% for Pb 2% have been reported Rate of these elements is less than the standard limit [18].
DeterminationElements (arsenic, lead, chromium and cadmium) in 11 samples of domestic and imported black tea cultivation in India By)ICP-AES)	The lowest of these elements has been reported that the lower limit [31].
Detection of heavy metals (cadmium and lead) in 30 samples of black tea imported and Iranian Using the atomic absorption method	The governor metals lower limit of the average level of heavy metals. Also visible in the Iranian black tea than imported ones higher [32].

Table 4. amount of toxic heavy metals in vegetables in Iran

Studies	Results
The heavy metals cadmium and lead in 60 samples of edible vegetables lettuce, mint and vegetables grown in five southern region of Tehran Using the atomic absorption method	In the case of lead and cadmium contamination maximum permissible amounts of vegetables for human consumption according to EU Europe has been further. The difference between the average concentration of cadmium in three leeks, lettuce and mint in the study areas was significant [33].
Detection of heavy metals (chromium, arsenic, lead and cadmium) in 100 samples of edible vegetables of choice Using the atomic absorption method	Levels of lead, cadmium and chromium in the city of Sanandaj were higher than the limit FAO / WHO [34].
Determination of heavy metals (lead, chromium and cadmium) in 150 samples of farmed vegetables around town shahrood Using the atomic absorption method	In 95% of cases except for arsenic, chromium, cadmium and lead was higher than the international standards [6].
Determination of heavy metals (lead and cadmium) in 25 samples of vegetables Rey By ICP-MS	Lead and cadmium concentration in all samples was higher than the international limit [35].
Cadmium absorption and accumulation in different parts of the bean, radish and pumpkin Using the atomic absorption method	Cadmium concentrations in edible portions of the samples (red beans, pumpkin radish root and fruit) were lower in the United States for agriculture and human standards [36].
Detection of heavy metals cadmium and lead in 205 samples of vegetables grown in the province of Zanjan (Beets, Fava Beans, leek, parsley, watermelon, melon, tomatoes, cucumbers, potatoes, onions, garlic, radishes and peas) Using the atomic absorption method	The highest cadmium in Chard, Fava Beans, Leek was Lead was highest in leaf parsley While all vegetables seeds (peas and beans), vegetables gland: the onion and garlic, lead concentration was unmeasurable [37].

Table 5. The amount of toxic heavy metals in the meat in Iran.

Studies	Results
Determining the concentration of cadmium in 48 samples of grilled chicken (liver and kidney) Using the atomic absorption method	In all samples, the average concentration of cadmium accumulated in the liver was higher in chickens [38].
Concentrations of metals (cadmium, lead and chromium) in 40 muscle cattle, calves, sheep in Sanandaj Using the atomic absorption method	Lead and cadmium concentrations were higher in samples of cow And high levels of chromium in the samples of sheep Concentrations in muscle samples are generally below the maximum acceptable concentration of Europe's Commission [39].
Determination of chromium, lead and cadmium (149 samples) edible organs (heart, liver and muscle) chickens supplied in Mashhad	High levels of these metals in the liver and kidneys were reported to muscles [3].

Using the atomic absorption method	
Determine the accumulation of lead and cadmium in 40 samples of muscle tissue of cattle slaughtered in Sanandaj Using the atomic absorption method	Concentrations in muscle samples was less than the maximum permitted levels acceptable for Europe [19].

Table 6. amount of toxic heavy metals found in dairy in Iran

Studies	Results
Determination of lead and cadmium in 250 samples of milk and dairy products from 5 industrial zone in Iran using thecathodicstripping voltammetry technique.	In nearly all cases the concentrations of the metals were below the international permissible limits and do not pose a health concern for the consumption of milk and dairy products in Iran [39].
Determine the level of lead residue in 97 samples of raw milk in 15 factories from different parts of Iran Using the atomic absorption method	About 90% of the samples were less than the newly established Codex standard: 20 ng/ml [2].
Determination of lead and cadmium concentrations in 137 samples of goat milk, cattle, sheep and buffalo from different regions of Iran Using the atomic absorption method	Lead concentration in 8.1% of sheep and 1.9% of cow milk samples was higher than the newly established Codex standard [5].
The remaining assess heavy metals (cadmium, mercury and lead) in dairy products (60 samples from five different brands) in Arak (ICP-SFMS) method.	28.3% (17 of 60 samples) of dairy products samples had lead (Pb) greater than EU limit and national Iranian standard (20 µg/kg) (Pb was high in yogurt, buttermilk, cheese, and milk was low; High mercury in yogurt, cheese, milk and yoghurt were low; High cadmium in yogurt, buttermilk, cheese, and milk was low)[40].

CONCLUSION

Based on the above data, the toxicity of heavy metals in foods such as vegetables and rice in some parts of the country was higher than the standard limit and regarding foods such as; tea, fruit and dairy products, no risk of poisoning has been reported. In case of seafood such as fish, some studies have shown high amount of mercury in fish caught from the shores of Persian Gulf which was above the standard limit. This amount was lower in the fish caught from the coast of the Oman Sea and inconsiderable in fish caught from north of Iran. This amount was almost zero in farmed fish.

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